Update on photon analysis

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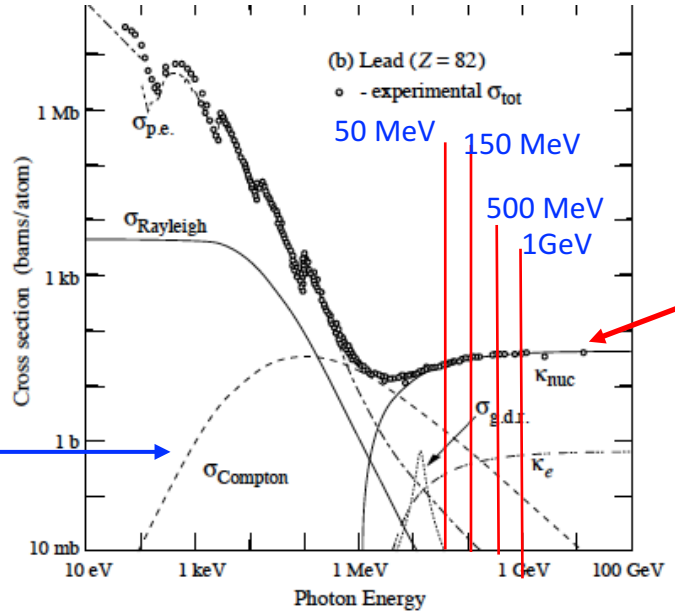
Photon cross section



Pair production

Compton scattering

Figure 27.15: Photon total cross sections as a function of energy in carbon and lead, showing the contributions of different processes [48]:

$\sigma_{\text{p.e.}}$ = Atomic photoelectric effect (electron ejection, photon absorption)

σ_{Rayleigh} = Rayleigh (coherent) scattering–atom neither ionized nor excited

σ_{Compton} = Incoherent scattering (Compton scattering off an electron)

κ_{nuc} = Pair production, nuclear field

κ_e = Pair production, electron field

$\sigma_{\text{g.d.r.}}$ = Photonuclear interactions, most notably the Giant Dipole Resonance [49]. In these interactions, the target nucleus is broken up.

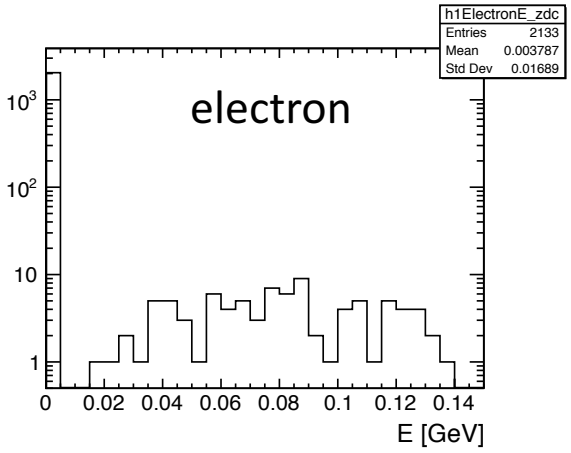
At low energy it is seen that the photoelectric effect dominates.
At 50-150MeV, the pair production dominates, although Compton scattering, photoelectric effect contribute.
At 150-500 MeV and 500MeV to 1 GeV, the increasing domination of pair production as the energy increasing, the Compton scattering contribution deceasing.

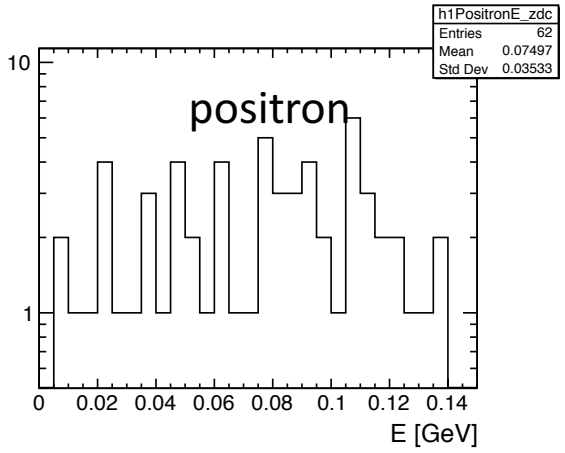
Photon gun (0-5mead)

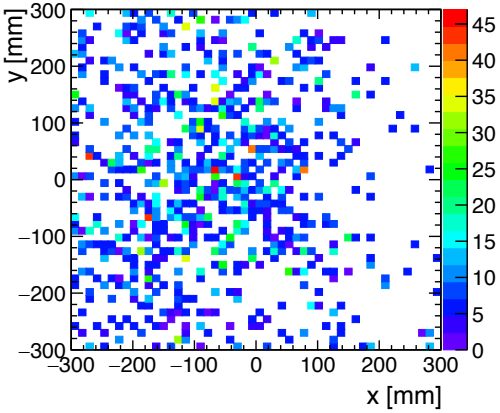
Photon gun: theta 0-5mrad

10k events

	50-150MeV	150-500MeV	0.5-1GeV
Photon Convert	3232	3354	3474
Convert rate	32.32%	33.54%	34.74%







BeAGLE run

1200 events

$e + Pb \rightarrow e' + J/\psi + X(p, n, \gamma)$ 18x110 GeV

Cut1:

- no neutron in ZDC

Cut2 :

- Cut1 + no photon ***E>50MeV*** in ZDC

Cut3:

- Cut2 + no proton in Roman Pots

Cut4:

- Cut3 + no proton in off-energy detector

Cut5:

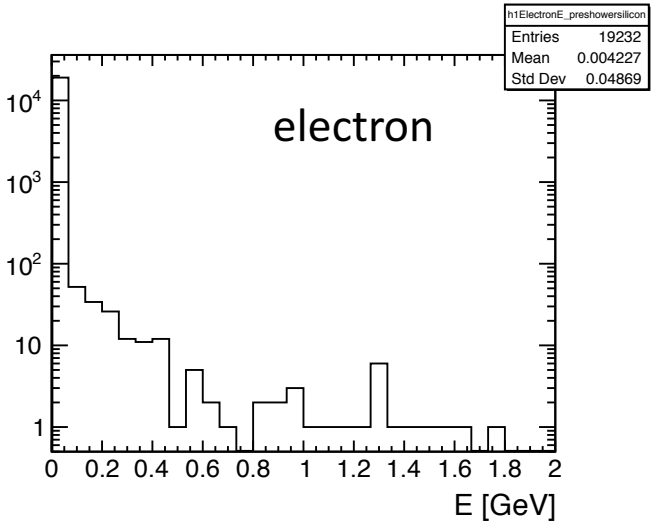
- Cut4 + no proton in B0

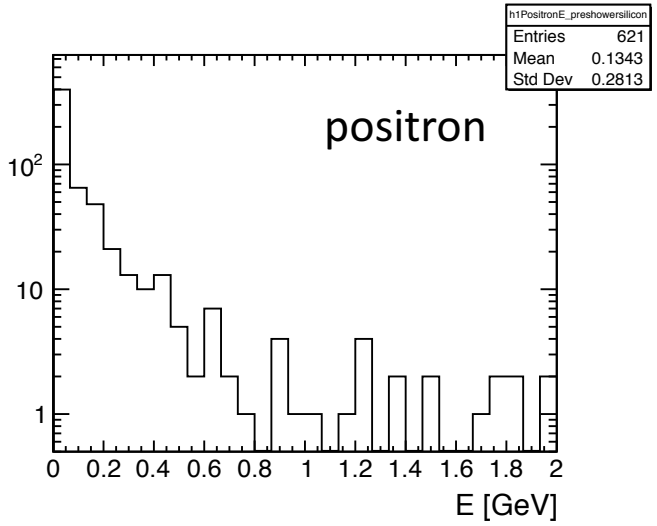
Cut6:

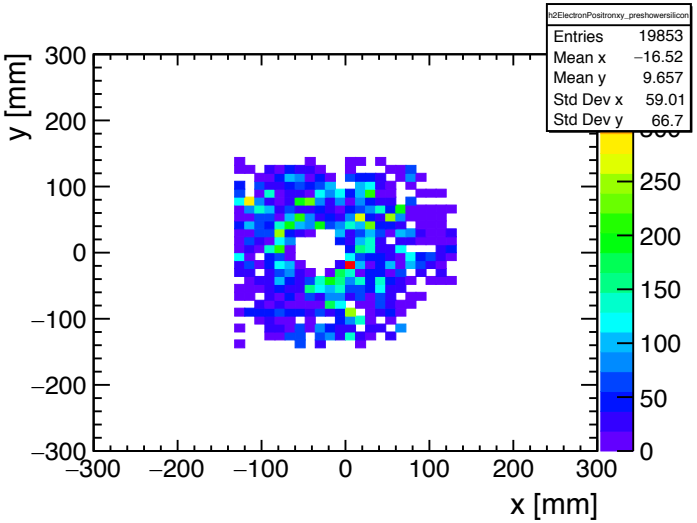
- Cut5 + no hits in preshower

Survived event count	
Total events	1200
Cut1	205
Cut2	143
Cut3	143
Cut4	141
Cut5	139
Cut6	60

BeAGLE run


h1ElectronE_preshowersilicon
Entries 19232
Mean 0.004227
Std Dev 0.04869
electron
E [GeV]


h1PositronE_preshowersilicon
Entries 621
Mean 0.1343
Std Dev 0.2813
positron
E [GeV]

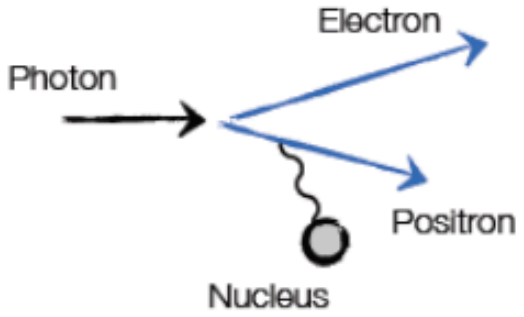

h2ElectronPositronxy_preshowersilicon
Entries 19853
Mean x −16.52
Mean y 9.657
Std Dev x 59.01
Std Dev y 66.7
y [mm]
x [mm]

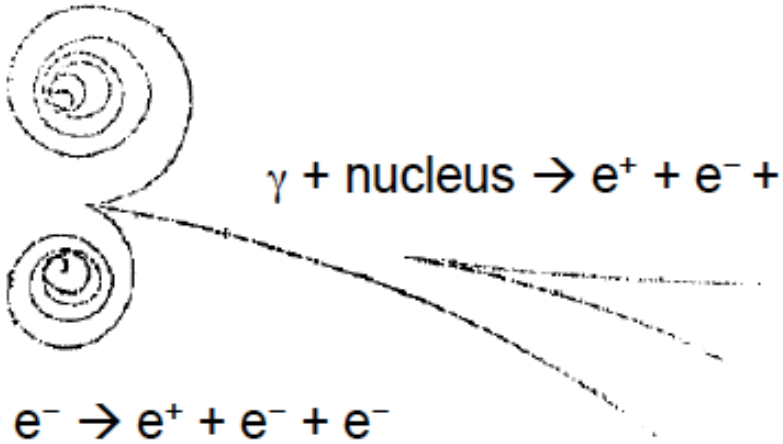
Back up

Pair production

Minimum energy required for this process
$2\ m_e$ + Energy transferred to the nucleus

$$E_\gamma \geq 2m_e c^2 + \frac{2m_e c^2}{m_{Nucleus}}$$

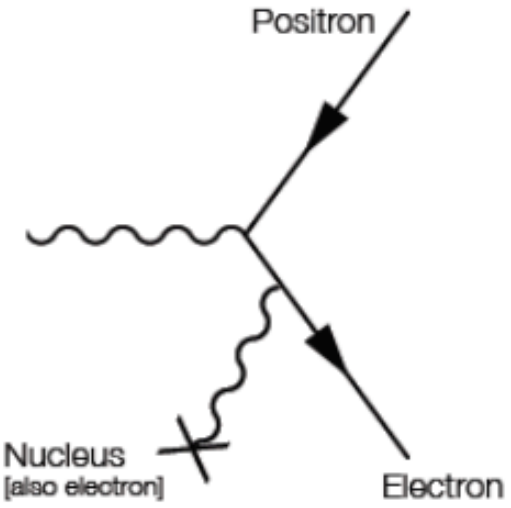




γ + nucleus → $e^+ + e^- +$ nucleus'

$\gamma + e^- \rightarrow e^+ + e^- + e^-$

γ + atom → $e^+ + e^-$



Compton scattering

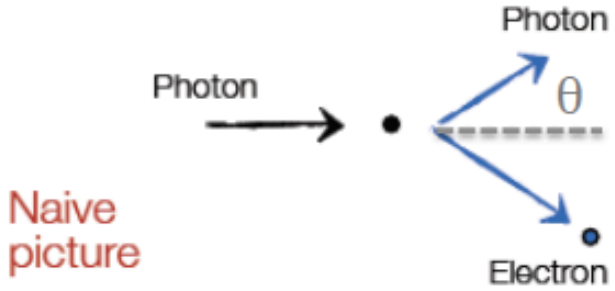
Best known electromagnetic process (Klein–Nishina formula)

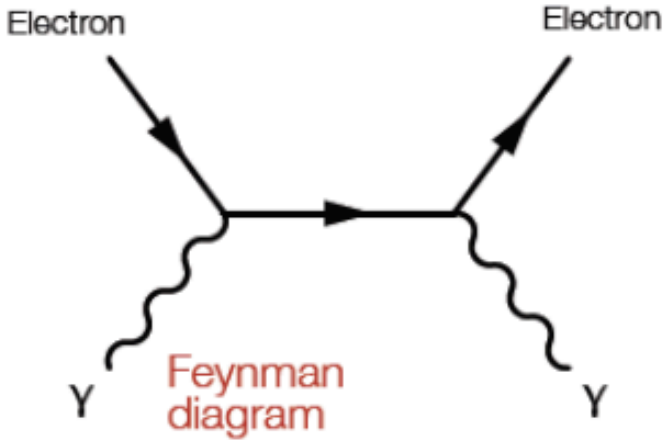
for $E_\lambda << m_e c^2$ $\quad \sigma_c \propto \sigma_{Th}(1-2\varepsilon)$

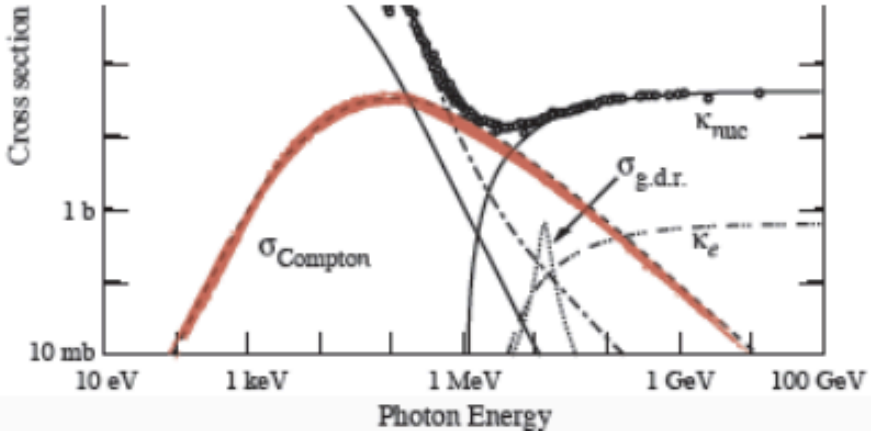
Thompson cross-section:
$\sigma_{Th} = 8\pi/3\ r_e^2 = 0.66$ barn

$$\varepsilon = \frac{E_\lambda}{m_e c^2}$$

for $E_\lambda >> m_e c^2$ $\quad \sigma_c \propto \frac{\ln \varepsilon}{\varepsilon} Z$





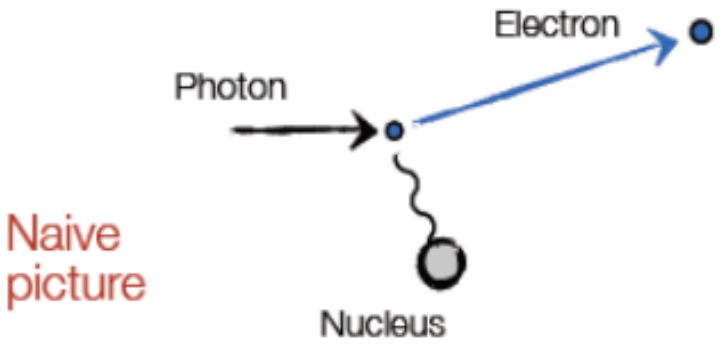


Photoelectric effect

From energy conservation:

$$E_e = E_\gamma - E_N = h\upsilon - I_b$$

I_b = Nucleus binding energy
introduces strong Z dependence



Cross-section largest for E_γ ≈ K-shell energy
Strongest E dependence for $I_0 < E_\gamma < m_e c^2$

$$\sigma_{ph} = \alpha\pi a_B^2 Z^5 (I_0 / E_\gamma)^{7/2}$$

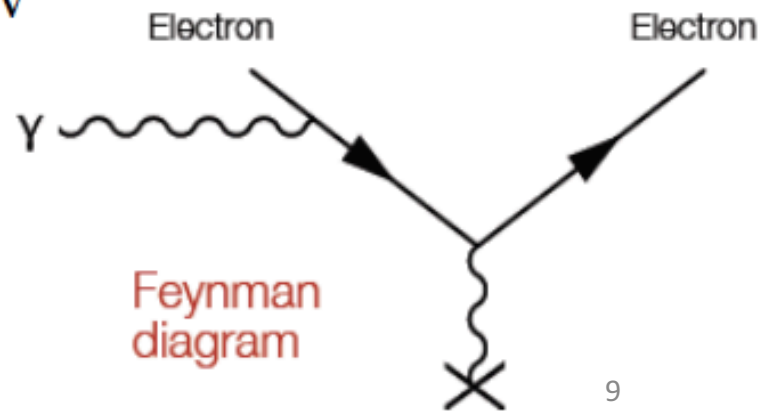
$a_B = 0.53$ Å

$I_0 = 13.6$ eV

γ + atom → e^- + atom$^+$

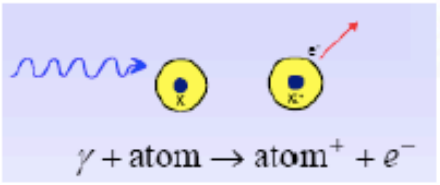
E-dependence softer for $E_\gamma > m_e c^2$

$$\sigma_{ph} = 2\pi r_e^2 \alpha^4 Z^5 (mc)^2 / E_\gamma$$

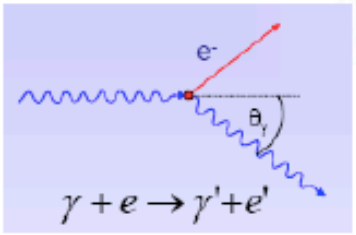


Electromagnetic interactions

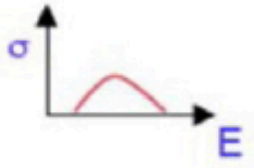
Gammas

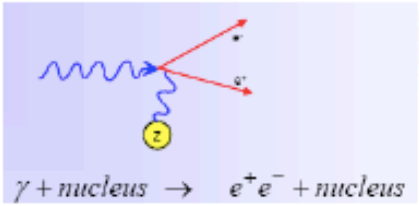


- Photoelectric effect

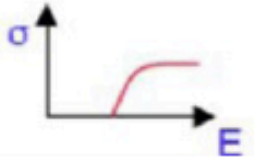


- Compton effect



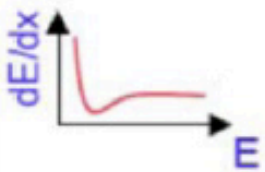


- Pair production



Electrons

- Ionisation



- Bremsstrahlung